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Runoff and soil loss from ultra-narrow row cotton plots with and without stiff-grass hedges

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Abstract

Grass hedges and no-till cropping systems reduced soil losses on standard erosion plots in ultra-narrow row (20 cm) cotton during a 4-year study (1999–2002). No-till cotton with grass hedges, no-till cotton without grass hedges, conventional-till cotton with grass hedges, and conventional-till cotton without grass hedges produced 4-year average annual soil losses of 1.8, 2.9, 4.0, and 30.8 t ha^{-1}, respectively, and produced 4-year average runoff amounts of 267, 245, 353, and 585 mm, respectively. The annual ratio of soil loss for no-till ultra-narrow row cotton plots with grass hedges to those without hedges averaged 0.62. The annual ratio of soil loss for conventional-till plots with grass hedges to without hedges was 0.13. Averaged over all plots (with and without grass hedges), no-till plots had 86% less soil loss than conventional-till plots. No-till plots without grass hedges had 90% less soil loss than conventional-till plots without grass hedges. Grass hedges effectively reduced soil loss on erosion plots with similar cropping practices as compared to plots without hedges. Along with the reduced soil losses from no-till system as compared to conventional-till system, the no-till ultra-narrow row cotton system resulted in an average 0.2 t ha^{-1} yield increase as compared to the conventional-till system. Reduced soil loss and increased crop yield are both positive factors that the user should consider when adopting this cotton system. Other studies of contoured grass hedges on field-sized areas are being conducted to determine their applicability on larger areas with greater concentrations of runoff.
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1. Introduction

Grass hedges are narrow strips of stiff, erect dense grass planted close to the contour and can withstand concentrated flows that would bend and overtop finer vegetation (Dabney et al., 1995; Dunn and Dabney, 1996). Dabney et al. (1996) concluded that stiff-grass hedges planted across concentrated flow zones retard and spread out surface runoff, cause deposition of eroded sediment, and control ephemeral gully development.

McGregor et al. (1999) published runoff and soil loss data for no-till and conventional-till cotton plots (with and without stiff-grass hedges) for standard-row widths (100 cm) at Holly Springs, MS. These were the same plots as used in this ultra-narrow row (20 cm) study. Hedges were established in the spring of 1991. Original standard-row width treatments consisted of no-till cotton with grass hedges, no-till cotton without grass hedges, conventional-till cotton with grass hedges, conventional-till cotton without grass hedges, and no-till cotton without grass hedges but with a winter wheat cover crop.

Average annual crop year soil losses (1992–1994) were highest for conventional-till cotton without grass

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hedges followed by conventional-till cotton with hedges, no-till cotton without hedges, no-till cotton with hedges, and no-till cotton with winter wheat cover. No-till cropping practices effectively reduced soil losses as compared to conventional-till. Averaged overall plots (with and without grass hedges, but not including winter cover plots), no-till plots had 88% less soil loss than conventional-till plots. No-till plots without grass hedges had 57% less soil loss than conventional-till plots with grass hedges.

McGregor and Dabney (1993) reported reduced soil losses during the first growing season (1991) after establishment of grass hedges on these cotton plots, even though completely consolidated hedges were not produced. During the 1991 cotton growing season, soil loss on conventional-till plots with hedges was 31.4 t ha^{-1} as compared to 56.0 t ha^{-1} for conventional-till plots without hedges. During the same period, soil loss from no-till cotton with hedges averaged 1.8 t ha^{-1} as compared to 3.1 t ha^{-1} for no-till plots without hedges.

The USDA-ARS National Sedimentation Laboratory conducts other field studies on larger plots and watersheds to evaluate the upper limits of concentrated flow for grass hedges and to evaluate their potential for use in conservation tillage systems in a manner similar to terraces. The conservation objective is to cause sediment deposition above the hedges, disperse concentrated flow, and reduce ephemeral gully development.

This paper reports the runoff and soil losses for the Holly Springs ultra-narrow row cotton plots during 1999–2002 and evaluates the erosion control effectiveness of the stiff-grass hedges. Row ridges were not used in any of the ultra-narrow row treatments. Soil loss ratios (SLRs) are estimated for use in the revised universal soil loss equation (RUSLE) for ultra-narrow row cotton planted without row ridges.

Objectives of the study were to: (1) compare runoff from no-till and conventional-till, non-ridged ultra-narrow row, cotton plots with and without stiff-grass hedges; (2) evaluate the effectiveness of fully developed stiff-grass hedges for reducing erosion for cotton; and (3) estimate soil loss ratios for non-ridged ultra-narrow row cotton rows for use in soil loss prediction.

2. Procedure

The study was conducted at the North Mississippi Branch of the Mississippi Agricultural and Forestry Experiment Station, Holly Springs, MS. Erosion plots were 4 m wide and 22.1 m long on 5% slopes. Plots were equipped with FW-1 water level recorders, H-flumes, and N-1 Coshocton wheel sampling devices. Soils on the plots were predominantly Providence silt loam (*Typic Fragiudalfs*).

Stiff-grass (*Miscanthus sinensis Andersson*) plants that would develop into hedges were transplanted about 0.5 m up slope from the lower ends of standard erosion plots on 27 March 1991 (McGregor and Dabney, 1993). The grass hedge on each plot was a mixture of three accessions (designated 130, 129 and 128) of *Miscanthus sinensis Andersson*. Individual plants were about 0.2 m apart. The hedges were transplanted about a month before the initiation of research on runoff and soil loss comparisons on the erosion plots for conventional- and no-till cotton (*Gossypium hirsutum* L.).

Experimental design consisted of a randomized block design with four treatments (two tillages by two grasses) replicated twice over 4 years. Replicated ultra-narrow row cotton treatments included both no-till and conventional-till cotton with and without grass hedges. No-till in this study refers to planting cotton in plots with no tillage operations and only a chemical burndown for weed control. Conventional-till in this study refers to the tillage sequence of two overland passes with a rototiller. Planting on all plots was done with a Marliss no-till drill planter. Cotton was planted on flat beds. Rows were up-and-down hill on 5% slopes.

Grasses and weeds were controlled with chemicals. Fertilizer and lime additions were based on experiment station recommendations. As part of a related poultry litter efficiency study, nitrogen was applied using an annual application of 3.6 t ha^{-1} poultry litter. Cotton was planted on 3 May, 11 May, 15 May, and 21 May and was harvested on 8 October, 13 October, 26 October, and 24 October in 1999, 2000, 2001, and 2002, respectively.

In June of each year, all hedges were clipped to a height of 0.5 m. The hedges were clipped using an electric hedge trimmer and hand shears. The lengths of hedge trimmings were about 50–80 mm. All grass clippings and cut stems were removed from the plots. In August, the hedges were trimmed again after they had grown to heights averaging from 0.9 to 1.4 m. All clippings were removed from the plots and discarded. All clippings were removed from the plots so that the trapping efficiency of the completely developed hedges could be determined.

3. Results

3.1. Grass hedge growth characteristics

Hedges grew well during the first summer after being transplanted into the plots in the spring of 1991.

But gaps (0.08 m wide) developed at the end of the first growing season (McGregor and Dabney, 1993). Throughout the 1992–1994 study period, grass hedges on no-till and conventional-till plots developed in the same manner and with similar characteristics (McGregor et al., 1999). By the end of the 1994 crop year, grass hedges averaged 531 green stems m^{-2}, 975 dead stems m^{-2}, and had a base width of 0.6 m. The hedges were well developed by the 1999–2002 study period.

3.2. Rainfall, rainfall erosion index, and runoff

Table 1 presents the monthly and crop year annual rainfall, erosion index (EI), and runoff during the 1999–2002 crop years. The 4-year average monthly rainfall amounts were fairly evenly distributed throughout the year, except that slightly lower amounts occurred in the summer months. The 4-year average rainfall (Table 1) for the 1999–2002 crop years (May to April) was

Table 1
Rainfall, erosion index, and runoff by months and years during the 1999–2002 crop years

Year	Month	Rain (mm)	Erosion index (MJ mm (ha h)$^{-1}$)	Runoff			
				NT-G[a] (mm)	NT-WOG[a] (mm)	CT-G[a] (mm)	CT-WOG[a] (mm)
1999	M	108	436	31	16	36	69
	J	168	639	56	50	57	90
	J	89	685	22	18	29	30
	A	4	654	0	0	0	0
	S	26	31	0	0	0	0
	O	103	47	19	11	27	77
	N	40	47	0	0	0	3
	D	95	187	20	3	15	47
	J	49	47	0	0	0	2
	F	74	47	16	6	18	23
	M	100	187	20	5	28	23
	A	134	2103	20	4	43	32
	Crop year 1	990	5110	204	113	253	396
2000	M	57	78	7	5	11	24
	J	97	872	9	8	14	32
	J	18	187	0	0	0	0
	A	64	31	11	5	12	27
	S	20	78	0	0	0	0
	O	0	763	0	0	0	0
	N	185	623	23	19	32	79
	D	96	187	23	15	27	32
	J	97	124	8	2	6	15
	F	211	1371	81	33	107	154
	M	59	62	0	0	3	10
	A	137	530	32	30	43	63
	Crop year 2	1041	4906	194	117	255	436
2001	M	89	452	2	1	12	24
	J	89	779	27	34	38	45
	J	72	249	2	2	7	25
	A	100	965	7	5	17	29
	S	86	608	11	13	32	43
	O	200	3582	44	35	75	84
	N	311	2180	144	110	135	161
	D	200	1293	53	44	65	78
	J	184	732	56	43	40	83
	F	79	171	9	12	18	29
	M	256	576	64	67	82	133
	A	67	47	25	21	43	46
	Crop year 3	1733	11634	444	387	564	780
2002	M	215	1012	44	45	76	115
	J	45	62	3	2	3	12

Table 1 (*Continued*)

Year	Month	Rain (mm)	Erosion index (MJ mm (ha h)$^{-1}$)	Runoff			
				NT-G[a] (mm)	NT-WOG[a] (mm)	CT-G[a] (mm)	CT-WOG[a] (mm)
	J	82	2398	10	19	20	43
	A	119	373	6	17	24	55
	S	175	888	24	14	21	104
	O	235	342	56	116	52	120
	N	89	93	10	14	18	38
	D	194	825	36	51	22	102
	J	16	0	0	0	0	0
	F	193	373	24	59	42	93
	M	75	0	8	13	17	30
	A	78	390	5	14	43	26
	Crop year 4	1516	6756	226	364	338	738
Average	M	117	495	21	17	34	58
	J	100	588	24	24	28	45
	J	65	880	9	10	14	25
	A	72	506	6	7	13	28
	S	77	401	9	7	13	37
	O	135	1184	30	41	39	70
	N	156	736	44	36	46	70
	D	146	623	33	28	32	65
	J	87	226	16	11	12	25
	F	139	491	33	28	46	75
	M	123	206	23	21	33	49
	A	104	768	21	17	43	42
	Crop year	1321	7102	267	245	353	585

Note: During 19-year period (1982–2000 calendar years), EI at Holly Springs was 91.5% of that at Goodwin Creek Watershed, so values in table estimated using this relationship. Sum of 4-year monthly averages may be slightly different from averages of annual total due to rounding.

[a] NT: no-till; CT: conventional-till; G: grass hedge; and WOG: without grass hedge.

1321 mm, similar to the 30-year normal rainfall of 1372 mm for North Central Mississippi (McGregor et al., 1987) and similar to the 1386 mm of rainfall during the earlier 1992–1994 standard-row width cotton study.

The rainfall EI for a storm is a function of the product of storm kinetic energy and the maximum storm 30 min rainfall intensity. The annual EI used in RUSLE is the expected sum of EI for all storms (McGregor et al., 1995).

The 4-year average EI of 7104 MJ mm (ha h)$^{-1}$ was 30% higher than the long-term expected EI used in RUSLE for Holly Springs (Renard et al., 1997). The 3-year average of 7804 MJ mm (ha h)$^{-1}$ during the 1992–1994 study was 43% higher than the long-term expected EI.

Hedges reduced average annual runoff on conventional-till cotton plots by 40%, but runoff from no-till plots with hedges was 9% higher than from no-till plots without hedges (Table 1). However, the runoff from all no-till plots (with and without hedges) was 45% less than runoff from all conventional-till plots. Average annual runoff was highest (Table 1) for conventional-till cotton without grass hedges followed by conventional-till cotton with hedges, no-till cotton with hedges, and no-till cotton without hedges. The 4-year average runoff amounts were 267, 245, 353, and 585 mm for no-till with hedges, no-till without hedges, conventional-till with hedges, and conventional-till without hedges. The 4-year average monthly runoff amounts were lowest in January, July, August, and September for all plots.

Generally, runoff differences from no-till plots with and without hedges were small. The 4-year average monthly runoff differences for these plots exceeded 5 mm only during October and November (11 and 8 mm, respectively). Average monthly runoff differences for conventional-till plots exceeded 15 mm in all but 4 months.

3.3. Soil loss

Hedges reduced average annual soil loss on conventional-till cotton plots by 87% and on no-till plots by 37% during 1999–2002 crop years as compared to 76% and 58%, respectively, during the 1992–1994 crop years. Average annual soil losses were highest (Table 2) for conventional-till cotton without grass

Table 2
Soil losses by months and years during the 1999–2002 crop years

Year	Month	Rain (mm)	Soil loss			
			NT-G[a] (t ha^{-1})	NT-WOG[a] (t ha^{-1})	CT-G[a] (t ha^{-1})	CT-WOG[a] (t ha^{-1})
1999	M	108	1.46	0.45	3.00	18.97
	J	168	0.36	0.39	1.93	22.44
	J	89	0.00	0.11	0.35	4.35
	A	4	0.00	0.00	0.00	0.00
	S	26	0.03	0.00	0.00	0.00
	O	03	0.00	0.00	0.04	0.94
	N	40	0.03	0.00	0.00	0.01
	D	95	0.00	0.02	0.02	0.28
	J	49	0.19	0.00	0.00	0.03
	F	74	0.05	0.07	0.15	1.28
	M	100	0.10	0.01	0.03	0.69
	A	134	0.00	0.01	0.04	0.26
	Crop year 1	990	2.22	1.06	5.56	49.25
2000	M	57	0.17	0.27	0.39	4.78
	J	97	0.09	0.15	0.33	3.62
	J	18	0.00	0.00	0.00	0.00
	A	64	0.12	0.04	0.07	1.38
	S	20	0.00	0.00	0.00	0.00
	O	0	0.00	0.00	0.00	0.00
	N	185	0.21	0.36	0.36	2.84
	D	96	0.49	0.43	0.62	3.21
	J	97	0.01	0.03	0.04	0.20
	F	211	0.41	0.31	0.68	4.08
	M	59	0.00	0.00	0.00	0.20
	A	137	0.18	0.46	0.49	2.03
	Crop year 2	1041	1.68	2.05	2.98	22.34
2001	M	89	0.01	0.03	0.23	2.51
	J	89	1.02	3.54	1.99	10.35
	J	72	0.01	0.05	0.14	2.15
	A	100	0.04	0.05	0.14	1.01
	S	86	0.03	0.09	0.17	0.80
	O	200	0.10	0.26	0.25	1.74
	N	311	0.56	0.73	0.30	2.33
	D	200	0.10	0.22	0.18	0.73
	J	184	0.18	0.42	0.38	2.63
	F	79	0.02	0.05	0.05	0.41
	M	256	0.10	0.40	0.26	1.34
	A	67	0.13	0.13	0.20	2.09
	Crop year 3	1733	2.30	5.97	4.29	28.09
2002	M	215	0.23	0.66	0.88	6.68
	J	45	0.01	0.01	0.10	0.87
	J	82	0.15	0.51	0.46	6.71
	A	119	0.02	0.21	0.25	3.69
	S	175	0.02	0.04	0.06	1.16
	O	235	0.59	0.83	0.32	2.35
	N	89	0.01	0.02	0.02	0.13
	D	194	0.07	0.17	0.65	0.65
	J	16	0.00	0.00	0.00	0.00
	F	193	0.03	0.10	0.22	0.63
	M	75	0.01	0.04	0.03	0.24
	A	78	0.01	0.02	0.02	0.17
	Crop year 4	1516	1.15	2.61	3.01	23.28

Table 2 (*Continued*)

Year	Month	Rain (mm)	Soil loss			
			NT-G[a] (t ha^{-1})	NT-WOG[a] (t ha^{-1})	CT-G[a] (t ha^{-1})	CT-WOG[a] (t ha^{-1})
Average	M	117	0.47	0.35	1.13	8.24
	J	100	0.37	1.02	1.09	9.32
	J	65	0.04	0.17	0.24	3.30
	A	72	0.05	0.08	0.12	1.52
	S	77	0.02	0.03	0.06	0.49
	O	135	0.17	0.27	0.15	1.26
	N	156	0.20	0.28	0.17	1.33
	D	146	0.17	0.21	0.37	1.22
	J	87	0.10	0.11	0.11	0.72
	F	139	0.13	0.13	0.28	1.60
	M	123	0.05	0.11	0.08	0.62
	A	104	0.08	0.16	0.19	1.14
	Crop year	1321	1.85	2.92	3.99	30.76

[a] NT: no-till; CT: conventional-till; G: grass hedge; and WOG: without grass hedge.

hedges followed by conventional-till cotton with hedges, no-till cotton without hedges, and no-till cotton with hedges. The 4-year average (1999–2002) soil losses were 1.8, 2.9, 4.0, and 30.8 t ha^{-1} as compared to 2.2, 5.2, 12.3, and 48.5 t ha^{-1} during the 3-year average (1992–1994) soil losses for no-till with grass hedges, no-till without hedges, conventional-till with hedges, and conventional-till without hedges, respectively. The higher soil losses during the earlier study can be partly attributed to significantly higher erosion index although the rainfall was only slightly higher.

No-till cotton plots with and without grass hedges adequately controlled annual soil losses to less than the tolerance value of 7 t ha^{-1} whereas conventional-till cotton plots did not during the 1992–1994 crop years. But during the 1999–2002 crop years, conventional-till plots with hedges, as well as no-till plots with and without hedges, controlled annual soil losses to less than the tolerance value of 7 t ha^{-1}.

About 16% and 15% of the annual rainfall and annual erosion index during the 1999–2002 crop years occurred during the combined months of May and June, during the early growth stages of the ultra-narrow row cotton. About 56% and 57% of the annual soil loss from conventional-till plots with hedges and conventional-till plots without hedges occurred during May and June. For conventional-till plots, soil loss during May and June averaged only 2.2 t ha^{-1} with hedges as compared to 17.6 t ha^{-1} without hedges.

The 1999–2002 study again illustrated the effectiveness of no-till cropping practices in reducing soil losses as compared to conventional-till. Averaged over all plots (with and without grass hedges), no-till plots had 86% less soil loss than conventional-till plots. Averaged over all plots, no-till plots had 88% less soil loss than conventional-till plots during the earlier 1992–1994 study.

3.4. Ratios of soil loss with and without grass hedges

The effect of grass hedges in reducing soil loss was determined by dividing the average soil loss of no-till cotton plots with hedges by the average soil loss of no-till cotton plots without hedges.

The annual ratio of soil loss for no-till ultra-narrow row cotton plots with grass hedges to those without hedges averaged 0.62. The annual ratio of soil loss for conventional-till plots with grass hedges to without hedges was 0.13.

An erosion control practice factor (P-factor) could be used in RUSLE to give some credit for grass hedges. McGregor et al. (1999) reported that the ratios of grass hedges to without grass hedges would reflect 100% credit for soil loss trapped above the hedges. McGregor et al. (1999) observed that a higher value may need to be used so that credit for soil trapped immediately above hedges will not be considered applied over the entire plot area.

3.5. C-factor estimates

The cropping and management C-factor for use in the USLE and later in the RUSLE is defined as the ratio of soil loss from land cropped under specified conditions to the corresponding loss from tilled continuous fallow land (Wischmeier and Smith, 1978). The ratio calculated for a crop stage is referred

Table 3
Annual soil loss ratios computed using measured soil losses and estimated annual EI values

Crop year	Rain (mm)	Erosion index (MJ mm (ha h)$^{-1}$)	Narrow row (20 cm)		Cotton study	
			NT-G[a] P(SLR)[b]	NT-WOG[a] (SLR)	CT-G[a] P(SLR)	CT-WOG[a] SLR
1999	990	5110	0.015	0.007	0.037	0.327
2000	1041	4906	0.012	0.014	0.021	0.155
2001	1733	11634	0.007	0.017	0.013	0.082
2002	1516	6756	0.006	0.013	0.015	0.117
Average	1320	7102	0.010	0.013	0.022	0.170
Crop year	Rain (mm)	Erosion index (MJ mm (ha h)$^{-1}$)	Standard-row (100 cm)		Cotton study[c]	
			NT-G P(SLR)	NT-WOG (SLR)	CT-G P(SLR)	CT-WOG SLR
1992	1464	7984	0.011	0.019	0.052	0.256
1993	1376	6792	0.005	0.008	0.027	0.109
1994	1343	8660	0.013	0.037	0.073	0.248
Average	1394	7812	0.010	0.021	0.051	0.204

[a] NT: no-till; CT: conventional-till; G: grass hedge; WOG: without grass hedge.
[b] SLR = 33.95(soil loss/EI) for plots without hedges, and where P (the erosion control practice value in RUSLE) equals 1.0; but P(SLR) = 33.95(soil loss/EI) for plots with hedges and the value of P is less than 1.0. Holly Springs EI estimated as being 91.5% of EI measured at Goodwin Creek Watershed based on 19 years of records at both locations. P(SLR) is the product of the P-factor and the annual soil loss ratio (or annual C-factor). P(SLR) values are shown for plots that had grass hedges. SLR is the crop year annual soil loss ratio or "annual C" factor. SLR values are shown for plots without hedges.
[c] Previous study from McGregor et al. (1999).

to as a soil loss ratio. Mutchler et al. (1985) reported that SLR values for the erosion plots at Holly Springs can be computed with the following equation:

$$\mathrm{SLR} = 33.95 \times \frac{\text{measured soil loss during crop stage}}{\text{measured EI during crop stage}} \tag{1}$$

where soil loss units are in t ha^{-1}, and EI units are in MJ mm (ha h)$^{-1}$.

SLR values using the above equation are not valid for the plots with grass hedges. Part of the credit for lower soil loss with plots with grass hedges should be reflected in an erosion control practice factor in the USLE or RUSLE.

Table 3 shows rain and EI along with the annual crop year SLR values computed for no-till and conventional-till ultra-narrow row cotton planted on flat beds without grass hedges. Annual SLRs during 1999–2002 crop years were 0.007, 0.014, 0.017, and 0.013, respectively, for no-till ultra-narrow row cotton on flat beds. For conventional-till ultra-narrow row cotton on flat beds, these ratios were 0.327, 0.155, 0.082, and 0.117, respectively. Average annual SLRs during 1999–2002 crop years was 0.013 for no-till ultra-narrow row cotton on flat beds. For conventional-till ultra-narrow row cotton on flat beds, the average ratio was 0.170.

McGregor et al. (1999) published annual SLRs during 1992–1994 crop years of 0.019, 0.008, and 0.037, respectively, for no-till cotton on flat beds. For conventional-till cotton on flat beds, these ratios were 0.256, 0.109, and 0.248, respectively. Mutchler et al. (1985) reported annual SLR values for conventional-till cotton on ridges to be 0.217 for conventional-cotton after 11 years of no-till, and 0.408 for conventional-till cotton on ridges after 11 years of conventional-till. They reported annual SLR values for no-till cotton after reduced-till soybeans of 0.102.

3.6. Cotton yields and ground residues

Crop yield (Table 4) was found significant ($\alpha = 0.05$) when averaging all tillage treatments among years with 2001 and 2002 yields being higher than either 1999 or 2000. The highest yield was 2.1 t ha^{-1} in 2001, followed by 2002, 2000, and 1999 with 1.9, 1.2, 1.1 t ha^{-1}, respectively. The yearly residues that were left on the ground at harvest (Table 4) were significantly higher in 1999 than the other 3 years producing 5.25 t ha^{-1} as compared to 3.4, 3.6 and 3.8 t ha^{-1} in 2000, 2001, and 2002, respectively. The dry conditions of 1999 as seen in the monthly rain data displayed in Table 3 resulted in lack of boll and fruit development, thus lower crop yields and higher residues. Crop yield was found to be significantly higher for no-till as compared to conventional-till for 2001 and 2002 when comparing the respective average crop yields of 2.3–1.9 t ha^{-1} in 2001 and 1.9–1.8 in 2002. Crop yield was

Table 4
Crop yields and residues during the 1999–2002 crop years

Crop year	Treatment	Cotton yield ($t\ ha^{-1}$)	Residue ($t\ ha^{-1}$)
1999	NT-G[a]	0.99	4.9
	NT-WOG[a]	1.22	6.0
	CT-G[a]	1.11	5.2
	CT-WOG[a]	1.12	4.9
2000	NT-G	1.34	3.8
	NT-WOG	1.18	3.8
	CT-G	1.17	3.3
	CT-WOG	1.28	2.7
2001	NT-G	2.35	4.1
	NT-WOG	2.17	3.8
	CT-G	2.23	4.1
	CT-WOG	1.66	2.4
2002	NT-G	1.87	4.6
	NT-WOG	2.01	3.4
	CT-G	1.98	4.3
	CT-WOG	1.70	2.9
Average	NT-G	1.64	4.4
	NT-WOG	1.64	4.3
	CT-G	1.62	4.2
	CT-WOG	1.44	3.2

[a] NT: no-till; CT: conventional-till; G: grass hedge; and WOG: without grass hedge.

also significantly affected by the grass hedge in conventional-till treatments probably due to trapping moisture. In 2001 and in 2002, the crop yield of the conventional-till with grass as compared to conventional-till without grass hedge were 2.2 and 2.0 $t\ ha^{-1}$ as compared to 1.7 and 1.7 $t\ ha^{-1}$, respectively.

4. Summary and conclusions

Low soil loss ratios computed for use in soil loss prediction reflected the erosion control potential of non-ridged, no-till, ultra-narrow row cotton.

Average annual runoff was highest for ultra-narrow row cotton treatments of conventional-till without grass hedges followed by conventional-till cotton with hedges, no-till cotton with hedges, and no-till cotton without hedges. Runoff from all no-till plots (with and without hedges) was 45% less than runoff from all conventional-till plots. Hedges reduced average annual runoff on conventional-till cotton plots by 40%, but runoff from no-till plots with hedges was 9% higher than from no-till plots without hedges.

Ultra-narrow row cotton conventional-till plots with hedges as well as the no-till plots with and without hedges controlled annual soil losses to less than the tolerance value of 7 $t\ ha^{-1}$ during the 1999–2002 crop years. Average annual soil losses were highest for conventional-till cotton without grass hedges followed by conventional-till cotton with hedges, no-till cotton without hedges, and no-till cotton with hedges. Hedges reduced average annual soil loss on conventional-till cotton plots by 87% and on no-till plots by 37% during the 1999–2002 crop years.

Along with the reduced soil losses from no-till system as compared to conventional-till system, the no-till ultra-narrow row cotton system resulted in an average 0.2 $t\ ha^{-1}$ yield increase as compared to the conventional-till system. Reduced soil loss and increased crop yield are both positive factors the user should consider in adopting this cotton system.

References

Dabney, S.M., Meyer, L.D., Harmon, W.C., Alonso, C.V., Foster, G.R., 1995. Depositional patterns of sediment trapped by grass hedges. Trans. ASAE 38 (6), 1719–1729.

Dabney, S.M., Meyer, L.D., Dunn, G.H., Foster, G.R., Alonso, C.V., 1996. Stiff-grass hedges a vegetative alternative for sediment control. In: Proceedings of the 1996 Interagency Sedimentation Conference. Las Vegas, NV, 10–14 March 1996, Sponsored by Interagency Advisory Committee on Water Data, Subcommittee on Sedimentation, pp. X-62–X-69.

Dunn, G.H., Dabney, S.M., 1996. Modulus of elasticity and moment of inertia of grass hedge stems. Trans. ASAE 39 (3), 947–952.

McGregor, K.C., Bingner, R.L., Bowie, A.J., Foster, G.R., 1995. Erosivity index values for northern Mississippi. Trans. ASAE 38 (4), 1039–1047.

McGregor, K.C., Dabney, S.M., 1993. Grass hedges reduce soil loss on no-till and conventional till cotton plots. In: Bollich, P.K. (Ed.), Proceedings of the 1993 Southern Conservation Tillage Conference for Sustainable Agriculture. pp. 16–20.

McGregor, K.C., Dabney, S.M., Johnson, J.R., 1999. Runoff and soil loss from cotton plots with and without stiff-grass hedges. Trans. ASAE 42 (2), 361–368.

McGregor, K.C., Muller, R.A., Murphree, C.E., 1987. Comparison of extreme 1-day amounts of rainfall for coastal and north central regions of Mississippi. In: Proceedings of the 17th Mississippi Water Resources Conference, Jackson, MS, Water Resources Research Institute, Mississippi State, MS, 24–26 March 1987, pp. 73–78.

Mutchler, C.K., McDowell, L.L., Greer, J.D., 1985. Soil loss from cotton with conservation tillage. Trans. ASAE 28 (1), 160–163 168.

Renard, K.G., Foster, G.R., Weesies, G.A., McCool, D.K., Yoder, D.C. (coordinators), 1997. Predicting soil erosion by water: a guide to conservation planning with the revised soil loss equation (RUSLE). U.S. Department of Agriculture, Agric. Handbook no. 703, 404 pp.

Wischmeier, W.H., Smith, D.D., 1978. Predicting rainfall erosion losses—a guide to conservation planning. USDA, Agric. Handbook no. 537, Washington, DC.